

EXHIBIT F

[DR. VILKE'S PUBLICATION]
TO DECLARATION OF MELANIE T. PARTOW IN SUPPORT OF
PLAINTIFFS' MOTIONS IN LIMINE 1-5

HEAD TRAUMA, PENETRATING

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BASICS

DESCRIPTION

Penetrating injury to intracranial contents:

- High-velocity penetration: Usually bullets, which cause trauma directly to brain tissue but also have a "shock wave" injury to local surrounding brain
- Low-velocity penetration: Usually knives, picks, or other sharp objects, with direct local trauma to brain tissue

ETIOLOGY

- Direct penetration of the skull into the intracranial cavity by foreign object:
 - Direct or local damage to brain tissue
 - Intracranial hemorrhage, including subdural, epidural, and intraparenchymal bleeds
- A bullet that hits the skull, ricochets off, and does not fracture the skull can still cause significant trauma to the underlying brain tissue.



DIAGNOSIS

SIGNS AND SYMPTOMS

- Alteration in level of consciousness and neurologic exam varies based on object and location.
- Evidence of increasing intracranial pressure:
 - Decreasing level of consciousness
 - Falling Glasgow Coma Scale score
 - Cushing response: Bradycardia, hypertension, and diminished respiratory rate
 - Blown pupil associated with decorticate or decerebrate posturing
- Evidence of penetrating injury to head or basilar skull fracture, or object still remaining in head:
 - Raccoon eyes: Bilateral ecchymosis of orbits associated with basilar skull fractures
 - Battle sign: Ecchymosis behind the ear at mastoid process associated with basilar skull fracture
 - Hemotympanum
 - CSF rhinorrhea or otorrhea

History

- Determine the weapon type or caliber of weapon at scene.
- Loss of consciousness (LOC) or amnesia for event
- Use of anticoagulants
- Headache, visual changes, or hearing loss
- Focal neurologic complaints

Physical Exam

- Evaluation of head evidence of penetrating injury and if a projectile, for multiple sites
- Complete neurologic examination
- Alteration in level of consciousness and neurologic exam varies based on object and location.
- Evidence of penetrating injury to head

ESSENTIAL WORKUP

- Thorough history and exam to assess extent of injuries
- Imaging study

DIAGNOSTIC TESTS & INTERPRETATION

Lab

- CBC
- Platelet count
- Coagulation perimeters
- Type and cross-match
- Electrolytes, BUN, and creatinine baseline levels

Imaging

- CT of head depicts location of lesion and extent of damage.
- Skull radiographs may reveal depth of impalement, location of bone fragments, and presence of fragments within the cranium.
- Cervical spine evaluation (when indicated):
 - Helical CT scanning or anteroposterior, lateral, and odontoid views plain radiographs

DIFFERENTIAL DIAGNOSIS

- Blunt head trauma
- Basilar skull fracture
- Any condition that alters mental status that may have induced a fall and caused secondary penetrating trauma



TREATMENT

PRE-HOSPITAL

- Stabilize but do not remove foreign object (eg, knife).
- Determine the weapon type or caliber of weapon at scene.
- Protect and manage the airway to avoid hypoxemia.
- Avoid hyperventilation.
- Maintain cervical spine precautions.
- Transport to trauma center.
- Avoid hypoxia (oxygen saturation <90%):
 - 100% oxygen
- Avoid hypotension (systolic BP <90 mm Hg):
 - Administer IV crystalloid solutions

INITIAL STABILIZATION/THERAPY

- Management of ABCs
- Rapid sequence intubation:
 - For Glasgow Coma Scale score <8, inability to protect airway, hypoxia, or cerebral herniation
 - Medications include etomidate or fentanyl as induction agent, succinylcholine (pretreat with minidose paralytic), rocuronium, or vecuronium; and morphine sulfate for ongoing sedation
 - Caution with fentanyl in the hemodynamically labile patient
 - Normalize Pco₂. Avoid hyperventilation or hypoventilation.
- IV catheter placement
- Crystalloid solution to maintain systolic BP >90 mm Hg
- Address other sources of associated trauma.
- Cervical spine precautions should be maintained.

ED TREATMENT/PROCEDURES

- Early neurosurgical consultation
- If patient has evidence of cerebral herniation (see "Signs and Symptoms"), initiate measures to decrease intracranial pressure:
 - Mild hyperventilation: 20 breaths per minute in adults, 25 breaths per minute in children, and 30 breaths per minute in infants <1 yr to keep ETCO_2 about 30–35 mm Hg.
 - Elevate head of bed 20–30 degrees.
 - Mannitol boluses IV: Do not administer mannitol unless systolic BP > 100 mm Hg and patient is adequately fluid-resuscitated.
- Phenytoin intravenously to prevent early posttraumatic seizures
- Reverse hypocoagulable states
- Glucocorticoids are *not* recommended to lower intracranial pressure in head trauma patients.
- Barbiturates are *not* recommended in the initial ED treatment.
- Transfuse as needed to keep hematocrit > 30%.
- If definitive neurosurgical care is not immediately available, a single burr hole may preserve life until neurosurgical intervention can be attained:
 - Perform only in comatose patients with decerebrate or decorticate posturing who have not responded to initial treatment on the side of a known mass lesion/hematoma.
- Avoid hypothermia, which will increase risks of coagulopathy during surgery.
- Maintain NPO status.
- Surgery:
 - Based on clinical and radiologic findings and neurosurgical consultation

MEDICATION

For RSI intubation, increased ICP, seizures, and pain control

First Line

- Etomidate: 0.2–0.3 mg/kg IV
- Fentanyl: 3–5 $\mu\text{g/kg}$ IV:
 - If systolic BP > 100 mm Hg
- Mannitol: 0.25–1 g/kg IV bolus
- Morphine sulfate: 2–20 mg IV (peds: 0.1 mg/kg up to adult doses)
- Phenytoin: 15–20 mg/kg IV up to 1,000 mg
- Rocuronium: 0.6 mg/kg IV
- Succinylcholine: 1–2 mg/kg IV
- Vecuronium bromide: 0.1 mg/kg IV:
 - Pretreatment minidose: 0.01 mg/kg IV

**FOLLOW-UP****DISPOSITION****Admission Criteria**

Admit all patients to ICU or transport directly to surgery.

Discharge Criteria

Do not discharge.

FOLLOW-UP RECOMMENDATIONS

All patients with penetrating skull injuries should have been admitted.

PEARLS AND PITFALLS

- Failure to query about anticoagulant use and image appropriately
- Failure to aggressively reverse hypocoagulable states

ADDITIONAL READING

- Badjatia N, Carney N, Crocco TJ, et al. Brain Trauma Foundation. *Guidelines for Prehospital Management of Traumatic Brain Injury*, 2nd ed. *Prehosp Emerg Care*. 2008;12(Suppl 1):S1–S52.
- Bratton SL, Chestnut RM, Ghajar J. Guidelines for the management of severe traumatic brain injury. Brain Trauma Foundation; American Association of Neurological Surgeons; Congress of Neurological Surgeons; Joint Section on Neurotrauma and Critical Care, AANS/CNS. *J Neurotrauma*. 2007;24 (Suppl 1):S1–S95.
- Committee on Trauma. *Head Trauma: Advanced Trauma Life Support*. 8th ed. Chicago: American College of Surgeons, 2008.
- Espinosa-Aguilar A, Reyes-Morales H, Huerta-Posada CE, et al. Design and validation of a critical pathway for hospital management of patients with severe traumatic brain injury. *J Trauma*. 2008;64(5):1327–1341.
- Warner KJ, Cuschieri J, Copass MK, et al. The impact of prehospital ventilation on outcome after severe traumatic brain injury. *J Trauma*. 2007;62(6):1330–1336.

See Also (Topic, Algorithm, Electronic Media Element)

- Head Trauma, Blunt
- Spine Injury: Cervical, Adult

**CODES****ICD9**

- 801.50 Open fracture of base of skull without mention of intracranial injury, with state of consciousness unspecified
- 853.10 Other and unspecified intracranial hemorrhage following injury, with open intracranial wound, with state of consciousness unspecified
- 873.8 Other and unspecified open wound of head without mention of complication